Thanks to the generosity of the Pacific Mail Steamship Company in passing the baggage free, Mr. Agassiz and his companion took to Peru a large outfit in the way of ropes, dredges, sounding-leads, thermometers for deep-water temperatures, and all the necessary materials for preserving large collections.

Though they were greatly disappointed in the variety of animal life found in the lake of Titicaca and the surrounding shore, they took some very interesting deep-water temperatures (to a depth of 154 fathoms), and completed a preliminary hydrographic sketch of the Lake, which has furnished valuable results, and done much to explain the poverty of its animal life.

The success of the Memorial-fund, of which we have spoken above, will, it is anticipated, enable the principal ideas of the late Professor Agassiz to be accomplished, so soon as the necessary additions to the buildings are completed.

"The foundation will then be laid of an institution in which the claims of college-students, of teachers, of special students, of advanced workers, and of original investigators will be considered, as far as the means and space of the establishment will allow. The public will find in the exhibition-rooms all that is likely to be of interest from the stores of the institution, labelled and arranged so as to be not only instructive, but suggestive.

"Of course time alone will enable us to fill out and complete this plan. We shall be compelled at first to make a very unequal exhibition, but as the blanks become apparent they will be filled.

"From our stores necessary materials for the constantly increasing number of students are to be supplied, and one of the chief duties of the Curator must always be to meet the reasonable demands of those charged with the instruction, by supplying them with ample materials suited to the wants of the different classes engaged in study at the Museum. The special students will have at their command, under proper regulations, in the store and work-rooms, of the assistants, the materials of the department in which they are interested.

"To the original investigator the resources of the Museum will always be available, under generous restrictions, with facilities for the publication of investigations made with Museum materials, as far as the means of the institution will allow. On the completion of the additions proposed at present, the Museum will thus consist of several departments of natural history, formerly separated in the University, and now all more or less intimately connected."

In concluding our notice of this report, we shall, we are sure, to be heartily joined by every European naturalist in wishing that these excellent plans of the Director of the Museum of Comparative Zoology may be speedily and efficiently carried out.

THE GREENWICH TIME SIGNAL SYSTEM[1]

II.

WE have now to speak of the use made of the time signals beyond the Observatory walls, and will first refer to the hourly currents passing to the Post Office. The original time-distributing apparatus was comparatively simple; afterwards Mr. C. F. Varley devised the chronopher, an elaborate system of switches and relays provided with an accurate clock for opening and closing the switches at the proper times, and forming together a complete automatic system; but on the transfer of the central telegraph station from Telegraph Street to the new building in St. Martin's-le-Grand, it was found necessary to add a second and much larger chronopher, shown in the accompanying drawing. It is to this apparatus that the Greenwich wire is led, and by which the single Greenwich current is simultaneously retransmitted on many different lines. These lines may be considered as divided into four groups:—1, the metropolitan; 2, the short provincial; 3, the medium provincial; and 4, the long provincial. The first group consists of wires passing to points in London; the second of wires passing to towns within a moderate distance of London, as Brighton, &c.; the third of wires passing to greater distances, as Hull, &c.; and the fourth of wires passing to towns or places at a considerable distance, as Belfast,[1] Edinburgh, Guernsey, &c. In each of the four groups the London ends of the several lines are brought into direct connection, each group having its separate battery and relay. On these four relays (the two at the left hand and two in the centre of the six shown) the current from Greenwich acts, and in each relay circuit the local battery current so divides that a portion of it passes out on every wire of the group.

The distribution in London takes place every hour; these wires, being used for time-signal purposes only, remain always connected to the metropolitan relay. To the country, distribution is made twice only on each day, at 10h. A.M. (by the new chronopher), and at 1h. P.M. (by the old chronopher), using the wires of the ordinary telegraphic service, which have, in consequence, to be specially switched into connection with the chronopher. The action at both hours is similar; we shall therefore describe only the 10h. A.M. distribution, which is the more extensive. Shortly before 10h. the chronopher clock (not shown in the sketch) sets in motion the clockwork train shown in the centre of the drawing; this turns over on its axis the flat bar (extending from side to side across the row of upright springs), which pushes the springs backwards, each one out of contact with its corresponding little square stud above. Each spring is in connection with a distant town or telegraph station, the corresponding stud communicating with its particular speaking instrument in the London office. As soon, therefore, as the springs are pushed back, the speaking instruments become all cut off, and the springs (representing distant stations) remain in contact with the long bar. This bar consists of three insulated portions, one for each of the three groups of provincial wires, each having its own battery and relay as before mentioned, and when it comes into contact with the springs in the way described, the distant stations all receive a constant current which serves as warning. On arrival of the Greenwich current at the chronopher the relays act and reverse these battery currents, and these reversals of current indicate at the distant stations the hour of 10h. A.M. precisely. Shortly after 10h. the clock-work train causes the long bar to turn back into its ordinary position, the springs become restored each to its respective stud, bringing the lines all into communication with their several speaking instruments, and the ordinary telegraphic work goes on as before. Of two relays on the right in the drawing, one (by action from the chronopher clock) opens out the relay coils a few seconds only before the hour, and so prevents interruption from accidental currents in the Greenwich line; the other is concerned in the Westminster clock signalling, spoken of further on. The galvanometers are for showing the passage of the various currents of which we have been speaking.

In some cases the current drops a time-ball on the roof of a building, in others a model time-ball is exposed to view in some place accessible to the public; sometimes the current acts on an electric bell, or ordinary galvanometer, and in some cases a gun is fired. The last-mentioned manner of communicating time to the public is one of the most generally useful for ordinary purposes, provided that the observer makes allowance for the rate at which sound

[1] Continued from p. 52.

[1] It is to be remarked that although the signals pass into Ireland, Greenwich time is counted only in Great Britain, Dublin time being counted throughout Ireland. In regulating clocks in Ireland by the Greenwich signals, allowance has therefore to be made for the constant difference between Greenwich time and Dublin time.

travels (about four miles in nineteen seconds). Time-guns are thus automatically discharged at 1 P.M. daily at Newcastle, Sunderland, Middlesboro', and Kendal.

The action of the apparatus, both at Greenwich and in the Post Office, is entirely automatic. Still, in the extension of the system, inquiries have sometimes been made as to the degree of exactness of signals received through the chronopher; the accuracy of its transmission has therefore been tested by direct experiment. One of its distributing wires was connected to a wire returning to Greenwich, so that the current leaving the Royal Observatory to act on the chronopher could be directly compared with that received at Greenwich from the chronopher. The currents were made to pass through galvanometers placed side by side, but there was no sensible difference in their indications. It follows, therefore, that entire confidence can be placed in the distribution by the chronopher.

As showing the extent to which demand for the automatic chronopher signals has increased, it may be mentioned that for some years past the *British Postal Guiae* has contained a tariff of annual charges for which the telegraph department will supply such signals and maintain the special connecting wires, both in London and the country.

The automatically transmitted signals are scientifically accurate, but a very extensive practical distribution of time is also made daily at 10 A.M. by hand contact. In

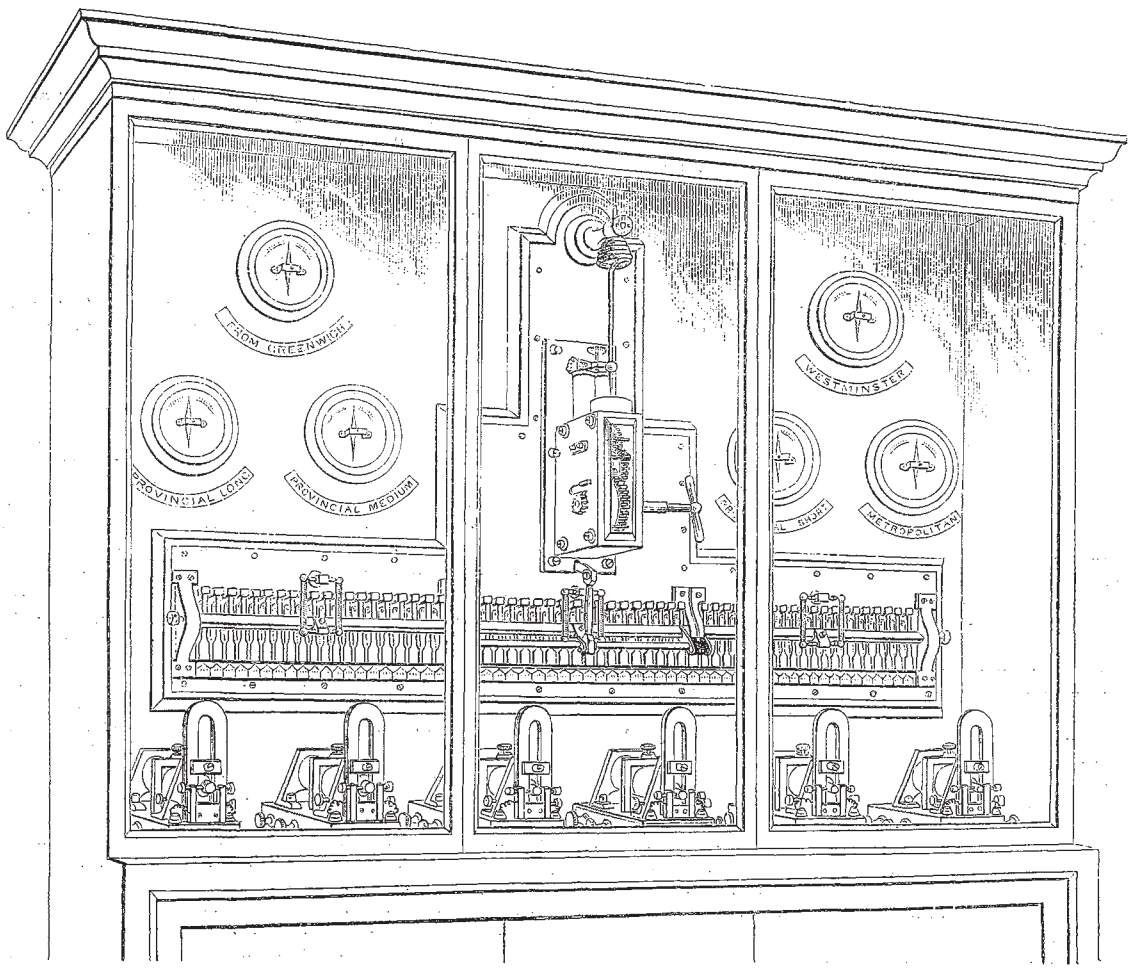

FIG. 2.—New Chronopher (or time distributing apparatus) in the Central Postal Telegraph Office, St. Martins-le-Grand.

the large instrument room of the central telegraph station a "sound" signal is established in connection with the chronopher. When heard at 10 A.M., the clerks, being in readiness, immediately transmit signals by their ordinary speaking instruments to above 600 offices in direct communication with the central station, including those in towns not supplied from the chronopher, the London offices, and the principal London railway termini. At many of these offices the signal is redistributed to others radiating from them, and so practically regulates most of the post-office and railway clocks of the country—these in their turn, insensibly as it were, regulating the clocks of the surrounding districts.

Thus, either by the accurate chronopher signal, or by the arrangement spoken of in the preceding paragraph, the 10h. current each morning from Greenwich, through the Post Office telegraph system, gives time simultaneously in all parts of the United Kingdom.

One of the chronopher lines in London passes to the clock-tower of the Westminster Palace, and hourly signals are received at the clock for its necessary rating and adjustment. It is, however, in no way controlled or mechanically acted upon by the time currents. Practically, the clock requires to be very rarely touched; if change becomes necessary, it is usually made by adding to or removing from the pendulum small auxiliary weights. The clock also completes a galvanic circuit at a certain time daily, and so transmitting a signal, reports

its rate at Greenwich. The statement of the Astronomer Royal in one of his annual Visitation Reports, that the rate of the clock "may be considered certain to much less than one second per week," does not, we believe, overestimate its performance. As regards its absolute variation from true time, we find, according to his last report, that on 83 per cent. of the days of the preceding year its error was below one second. We may mention that the clock has a gravity escapement, that the compensation of the pendulum is entirely metallic and generally similar to that of the Greenwich Sidereal Standard (described in our article on that clock), and that the first blow on the bell at the hour is true clock time, it having been made a condition in the construction of the clock that there should be no loss of time in the first stroke.

So far as regards the work done from one of the wires passing from the Royal Observatory: on the other, terminating at London Bridge, currents also pass from Greenwich hourly, which, with the exception of that at 1 P.M., are placed at the disposal of the South-Eastern Railway Company, who in return give to the Royal Observatory, for two or three minutes daily at 1h., communication between London Bridge and Deal for the purpose of dropping at the latter place a time signal ball belonging to the Admiralty, placed on the old semaphore tower (part of the now abolished Navy Yard). For communication with Deal at 1h. a clock at London Bridge (one of those before spoken of as being controlled from Greenwich) automatically switches the Greenwich wire into communication with a wire on the main line of the South-Eastern Railway. Other special connections are also daily made at Ashford and Deal before the current can pass uninterruptedly from the Observatory to the time-ball; immediately after 1h. the wires are restored to their former positions. To ensure that the ball has fallen properly at 1h., an arrangement exists by which, after its discharge and before it has completed its descent, it makes such momentary changes of the wire connections as cause a "return" signal to pass to Greenwich indicating that it has fallen. This ball was established by the Admiralty to give Greenwich time to shipping in the Downs, and has been in use since the year 1855. It is placed under the superintendence of the Astronomer Royal, who in his annual Visitation Reports gives statistics by which we can judge of its practical working. Examining these reports for the last few years we find, on the average, that about once in two months the ball was not raised on account of high wind, and that about once in six weeks, from accidental telegraphic fault, there was no discharge. An erroneous drop appears to be rare, happening once or so in a year. When such does occur, a black flag is at once hoisted as indication of mistake, and the ball is then dropped at 2h. The efficient working of the ball, thus distant from the Observatory, is considered by the Astronomer Royal to be mainly due to the establishment of the return signal which immediately makes known at Greenwich whether the ball has fallen in the usual way.

Excepting the 1h. current, used as described for the Deal ball, the remaining hourly currents to London Bridge are distributed by Mr. C. V. Walker mainly on the lines of the South-Eastern Railway. For this distribution the clock at London Bridge, already spoken of, switches at different hours different wires into connection with the Greenwich wire, and so passes on the Greenwich current; at some hours it goes to the office of the British Horological Institute in Clerkenwell, for the use of watch and chronometer makers.

It will be seen that the country generally is well served by the system now described, but a useful extension would be made by the establishment of authoritative signals in favourable positions on our coasts, for the purpose of giving to mariners the means of obtaining Greenwich time and approximate sea rates for their chronometers after leaving port. One coast signal only at present exists—the time-ball set up at Deal, as already described. Some few years after its erection, however, it was suggested that a time-signal should be also exhibited every hour at some headland of the southern coast, and after some discussion of localities, the Astronomer Royal proposed a detailed scheme for showing such signals on the Start Point. And more recently the Shipowners' Association of Liverpool made inquiry as to the facilities for exhibiting a similar hourly signal on the Tuskar Rock. Neither of these schemes has yet been carried into execution, but, excepting the question of cost, there seems to be otherwise no difficulty.

It was indicated in an early part of our article that one of the objects of connecting the Greenwich Observatory with the telegraphic system was the possible determination of differences of longitude between Greenwich and other observatories by the exchange of galvanic signals, and since such connection has existed, many important determinations of the kind have been made. We cannot here enter into any detailed description of the different plans that have been from time to time employed in practically carrying out such operations: it will be sufficient to say that the longitudes of the principal British and of some continental observatories have been thus determined. On two occasions Atlantic cables have been employed for fixing the positions of points in America, and more recently (in connection with the Egyptian expedition for observation of the late Transit of Venus) the longitude of Cairo has been by similar means determined. In the latter operation signals were exchanged between the submarine cable stations in Cornwall and Alexandria with perfect success, through one unbroken line of submarine wire. The telegraphic method of determining longitude is one of the most accurate that can be employed.

The connection of the Royal Observatory with the telegraph assists scientific inquiry and even commercial enterprise in various unexpected ways. Capt. Heaviside, R.E., having recently been engaged with some pendulum experiments at the Kew Observatory, it only became necessary to connect the telegraph line at Greenwich to the Sidereal Standard for a few minutes daily, to enable him to receive seconds signals through the Post Office wires, and so refer his observations directly to the Greenwich clock. Also, in the laying of Atlantic cables, an accurate knowledge of Greenwich time being of the greatest importance for the exact navigation of cable ships, Greenwich time has on such occasions been daily passed from the Royal Observatory through the cable itself, as it was being submerged, to the ship.

Our object has been simply to describe the Greenwich system, but we may mention that the plan of telegraphing time, first carried out at Greenwich as part of the daily routine, has since been adopted in other places. In Britain much has been done at the observatories of Liverpool, Edinburgh, and Glasgow, for the dissemination of a knowledge of accurate Greenwich time, both by public clocks and public signals, in the vicinities of those cities. A time-gun is fired daily both at Liverpool and Edinburgh by signal from the observatories of those places. Time-signal systems in connection with observatories are also in operation in various of our colonies, and in places abroad. In the United States of America several very extensive systems have of late years been established, and it has recently been proposed to regulate the clocks of Paris from the Paris Observatory.

The system of employing the ordinary telegraph service of a country for the daily transmission of time in many directions from a fixed observatory shows the benefit that may sometimes ensue from uniting for a special object the powers of two separate institutions of totally different character. The astronomer must for his own particular work obtain from the face of the sky that which, especially in our day, is also so useful to mankind, an accurate

knowledge of the flow of time. This he can, with slight additional trouble, communicate to the external world, although wanting the means of promulgation to any great extent. Telegraphs, on the other hand, exactly supply this want, and can spread abroad in all directions the astronomer's information. Before the transfer of the telegraphs to the State, the successful working of the Greenwich system was due entirely to the existence of amicable arrangements entered into by both parties. But now that the time-signal system is, as it were, consolidated, it might well receive greater development. The principal clocks, and those of public institutions, in our large cities and towns, London included, should be more directly regulated than is at present the case by the automatic signals which can be so readily supplied by telegraph, and which might usually be received (as at Westminster) in the clock tower or chamber, for direct comparison with each particular clock. In large towns one wire could be made to serve for many buildings, and the cost for each thus greatly reduced.

The efficient regulation of public clocks in the way mentioned is however a thing entirely for the consideration of the municipal bodies in the various cities and towns concerned. But it is otherwise with the question of the establishment of signals on our coasts for the giving of Greenwich time to outward-bound or passing vessels. This is a matter not merely of local, but of national interest; and, since the whole subject of the safety of our ships at sea is now under the consideration of the Imperial Legislature, it seems a proper time to direct attention to the usefulness of such coast-signals, as tending directly to the improvement of navigation, and thereby contributing in an important degree to the further protection of shipping.

MIGRATION AND HABITS OF THE NORWEGIAN LEMMING

WITH all our recent knowledge of the Northern Fauna, and the ample opportunities of the Scandinavian naturalists, the animal in question still seems to have evaded a thorough scrutiny and complete solution of the why and wherefore of its remarkable migrations. Ten consecutive summers spent in Norway have led Mr. W. Duppa Crotch,[1] in studying the creature, to propound a novel view as to the impetus of its recurrent irruptions. Passing by the traditional lore respecting its sudden appearance in myriads, he discountenances the later informed writers' explanation of hunger, or of the approach of severe weather, being the cause. Even "survival of the fittest," with its cogent subsidiary clauses, according to our author, fails to serve as a substantial reason, for, as he observes, none of the travellers survive. His own theory is a very simple one. The bands of migrants always head westward, and at last, in diminished numbers, perish in the sea. In one well authenticated instance (Collet), a ship sailed for fifteen minutes through a swarm, the water being literally alive with them far as the eye could reach. This migratory instinct, Mr. Crotch assumes, is hereditary, their progenitors in the good old times of geological age having sojourned in a land of plenty, now submerged beneath the Atlantic. According to him the migration is not all completed in one year, as formerly supposed, nor do they, as stated, form processions and cut their way through obstacles; but breeding several times in the season, they gather in batches, and at intervals make a move westward. Their pugnacity, he states, is astonishing, and the approach of any animal, or even the shadow of a cloud, arouses the anger of this small creature like a guinea-pig, and they back against a stone or rock uttering shrill defiance. Our author found, in most examples, a bare patch on the rump, due to their rubbing against the said buttress of support when at bay. He wonders why a bare patch, and not a callosity, should not result from this innate, apparently hereditary habit. They cross wide lakes by swimming, but when in the water they are easily frightened, and lose all idea of direction, and are inevitably drowned by a slight ruffling of the surface. It seems the reindeer trample them under foot whenever the chance may occur, and other enemies in the shape of hovering rapacious birds and small carnivora thin the numbers considerably as the Lemmings in force drive westward. The writer also called attention to the fact that fossil remains of the Lemming exist in England, as an evidence that the animal had penetrated hither before this island was severed from the continent. The subject altogether is a most interesting and suggestive one, well worthy of the investigation and observation of northern sojourners. Even the recent views of Mr. Crotch, it seems, does not set the whole question at rest. There possibly may be some physical or physiological reason underneath; at all events it is certainly remarkable how a settled westward course is that chosen, calling to mind the similar direction which races of men are assumed to follow.

[1] In a paper read before the Linnean Society, May 4.

THE SEYCHELLES ISLANDS[1]

THE Report mentioned below is dated 20th May, 1875, and refers to two visits made to the Islands of the Seychelles group in 1871 and 1874. The islands visited by Mr. Horne were Mahé, Praslin, Silhouette, La Digue, Félicité, Curieuse, Aux Frégates, St. Anne, and Aux Cerfs. The soil, climate and products of the islands are very similar, so that the remarks made are equally applicable to all of them. The climate is healthy, although the islands are situated almost under the equator, and the Cascade Valley in Mahé which is at an elevation of 1,500 feet above the sea, is pointed out as being especially delightful. The seasons are two, the warm and wet, during the north-west monsoon, from October to April: and the comparatively cool and dry season from April to October. The rainfall during the year is about 96 inches, most of which falls during the wet season.

Some of the islands have high mountain peaks, as Mahé, with an elevation of 3,000 feet, and Silhouette with an elevation of 2,500 feet; the highest land in the other islands is less than 1,500 feet. Lagoons often exist between the base of the mountain and the flat sandy beaches which exist in all the islands. In former times crocodiles were abundant in the lagoons, but they have now been extirpated.

The islands are granitic with veins of trap. Coral reefs are abundant but of small size, the largest being on the north-east of Mahé, and the north-east and south-west of Praslin. The surface of the islands is mountainous and undulating. Granitic boulders are common, and are most numerous near the mountain tops and in the bottom of ravines. The soil is rich and capable of producing any kind of crop peculiar to the tropics. In many places, however, the soil has been washed away, and some of the islands are almost bare rock. There is much uncultivated land, the greater proportion of which is good, but according to Mr. Horne, the people are either too lazy or too poor to cultivate it.

The chief produce of the islands is cocoa-nut oil and fibre. The plantations of cocoa-nut palms are increasing, and many of the young plants are now bearing, which they do when ten or twelve years old. The value of a plantation in full bearing is about three shillings per tree per annum. The oil is extracted by the old primitive mill which has been used in Ceylon and elsewhere for hundreds of years. The fibre is extracted by machinery and will soon

[1] Report on the Seychelles Islands. Addressed to the Honourable the Colonial Secretary, by J. Horne, Sub-Director Royal Botanical Gardens, Mauritius.